EE698W Convex Optimization for Signal Processing and Wireless Communications

1. Introduction and motivation
    a. Mathematical optimization, least-squares, linear programming
    b. Convex optimization, examples
    c. Course goals and topics, plan
    d. Other techniques: local & global opt, complexity, genetic opt.
    e. History of convex optimization
2. Mathematical background – norms and analysis
    a. Norms: examples, equivalence of norms, operator norms, <dual norms>
    b. Functional analysis: sets, sup & inf, continuity
3. Mathematical Background: Linear Algebra
    a. Range and nullspace, evd, scd, schur complement
    b. Matrix Calculus: derivatives, gradient, chain rule
4. Aspects of convex optimization: convex sets
    a. Affine set, convex set, convex hull, convex cone, half-space, norm balls and norm cones, polyhedral, positive semidefinite cone
    b. Checking convexity: intersection, affine, perspective, linear-fractional
    c. Supporting and separating hyperplanes
5. Aspects of convex optimization: convex functions
    a. Convex functions: properties, examples on $R_{m \times n}$
    b. Checking convex functions: first and second order conditions, epigraph, sublevel sets, Jensen's inequality, convexity-preserving operations, conjugate function
    c. Quasiconvex functions, properties, examples
    d. Log concave and log-convex functions, properties, examples
6. Convex optimization problem formulation and duality
    a. Convex optimization problems: standard form, conditions, implicit constraints, feasibility, local and global optimality, equivalent forms,
    b. Quasiconvex programming
    c. Linear Programming, examples,
    d. Linear-fractional programming
    e. QP, QCQP,
    f. Duality: lagrangian, dual problem, examples,
    g. Weak and strong duality, slater constraint qualification, examples
    h. Complementary slackness, KKT
    i. More examples of duality
7. Extra lecture: using CVX
8. Power allocation in MIMO/OFDM cognitive radios
    a. Cone Programming
    b. Generalized inequalities, dual cones, minimum and minimal elements
    c. Convexity wrt generalized inequalities
    d. SOCP, SDP optimization, LMI

    e. Application: Stochastic Programming
9. Signal reconstruction, approximation and fitting
10. Geometric programs, power control, optimization of Aloha networks
11. Robust designs: robust beamforming
12. Parameter estimation, channel estimation, MLE
13. Geometric problems, clustering, classification, LDA
14. Fairness-based resource allocation, quasiconvexity
15. Distributed network optimization, subgradient method
16. LASSO, compressed sensing
17. Robust designs: network anomaly detection
18. Support vector regression, face detection, pattern recognition
19. SDP relaxation, ML detection, covariance fitting
20. QCQP for beamforming, smart antennas
21. Multi-dimensional scaling, network visualization
22. Optimum experiment design, sensor placement, pilot design
23. Matrix completion, recommender systems, Internet geolocation,

Numerical Methods

1. Introduction to numerical linear algebra
    a. Complexity of matrix operations
    b. Solving linear equations, LU, Cholesky, LDL
    c. Rank updates, underdetermined linear equations
2. Unconstrained minimization
    a. Descent methods: gradient descent, steepest descent
    b. line search, newton method,
    c. examples
3. Equality constrained minimization
    a. Eliminating equality constraints
    b. Newton method with equalities
    c. Infeasible-start newton method
4. Interior point methods
    a. Barrier function and central path, interpretations
    b. Barrier method, feasibility, phase-I methods
    c. Generalized interior point for SDP